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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte RICHARD R. KING, CHRISTOPHER M. FETZER, and NASSER H. KARAM

Appeal 2016-003692
Application 13/617,566[1]
Technology Center 1700

Before MICHAEL P. COLAIANNI, WESLEY B. DERRICK, and CHRISTOPHER L. OGDEN, *Administrative Patent Judges*.

OGDEN, *Administrative Patent Judge*.

DECISION ON APPEAL

Appellants appeal under 35 U.S.C. § 134(a) from the Examiner's decision finally rejecting claims 1–13 and 15–18 in the above-identified application.[2] We have jurisdiction pursuant to 35 U.S.C. § 6(b).

We AFFIRM.

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[1] According to Appellants, the real party in interest is The Boeing Company. *See* Appeal Br. 3, Aug. 11, 2015.

[2] Final Office Action, Mar. 12, 2015 [hereinafter Final Action]; Examiner's Answer, Dec. 21, 2015 [hereinafter Answer].

BACKGROUND

Appellants' invention relates to "improved single-junction cells or subcells in a multijunction photovoltaic (PV) cell, especially a solar cell, having multiple layers to form a heterostructure." Spec. 1. Independent claim 1 is illustrative:

> 1. A photovoltaic cell comprising:
>
> a first layer comprising a p-n junction formed at a homojunction within the first layer, said first layer comprising a first layer group-IV material; and
>
> a second layer comprising a material selected from the group consisting of: a group III-V material and a second layer group-IV material different from the first layer group-IV material; wherein said second layer material comprises a material having the same doping type as the group-IV material in the first layer.

Appeal Br. 11. Independent claims 2 and 12 recite similar limitations. *See id.* at 11–13.

The Examiner maintains the following grounds of rejection:

I. Claims 1–3, 5–13, and 15–18 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1–5, 10–18, 21, and 23–26 of copending Application No. 13/617,316 in view of King.[3] *See* Final Action 3–4.

II. Claims 1–3, 5–13, and 15–18 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1, 3, 4, 11, 35, 39, 40, 42–45, 48, 53–55, 57–59, and 63–65 of copending Application No. 13/616,933 in view of King. *See* Final Action 4–5.

[3] King et al., US 2004/0200523 A1 (published Oct. 14, 2004).

III. Claims 1–7, 9–13, and 15–17 are rejected under 35 U.S.C. § 103(a) as being unpatentable over King. *See* Final Action 7–14.

IV. Claims 8 and 18 are rejected under 35 U.S.C. § 103(a) as being unpatentable over King in view of Fetzer.[4] *See* Final Action 14–16.

In the Appeal Brief, Appellants do not contest rejections I and II. *See* Answer 19. Regarding rejections III and IV, Appellants argue independent claims 1, 2, and 12 as a group. *See* Appeal Br. 4–9. Appellants make no distinct arguments regarding the dependent claims. *See id.* at 9. Therefore, consistent with 37 C.F.R. § 41.37(c)(1)(iv) (2016), we limit our discussion to claim 1. Claims 2–13 and 15–18 stand or fall with claim 1.

[4] Fetzer, US 2010/0229930 A1 (published Sept. 16, 2010).

DISCUSSION

Figure 1 of King is reproduced below:

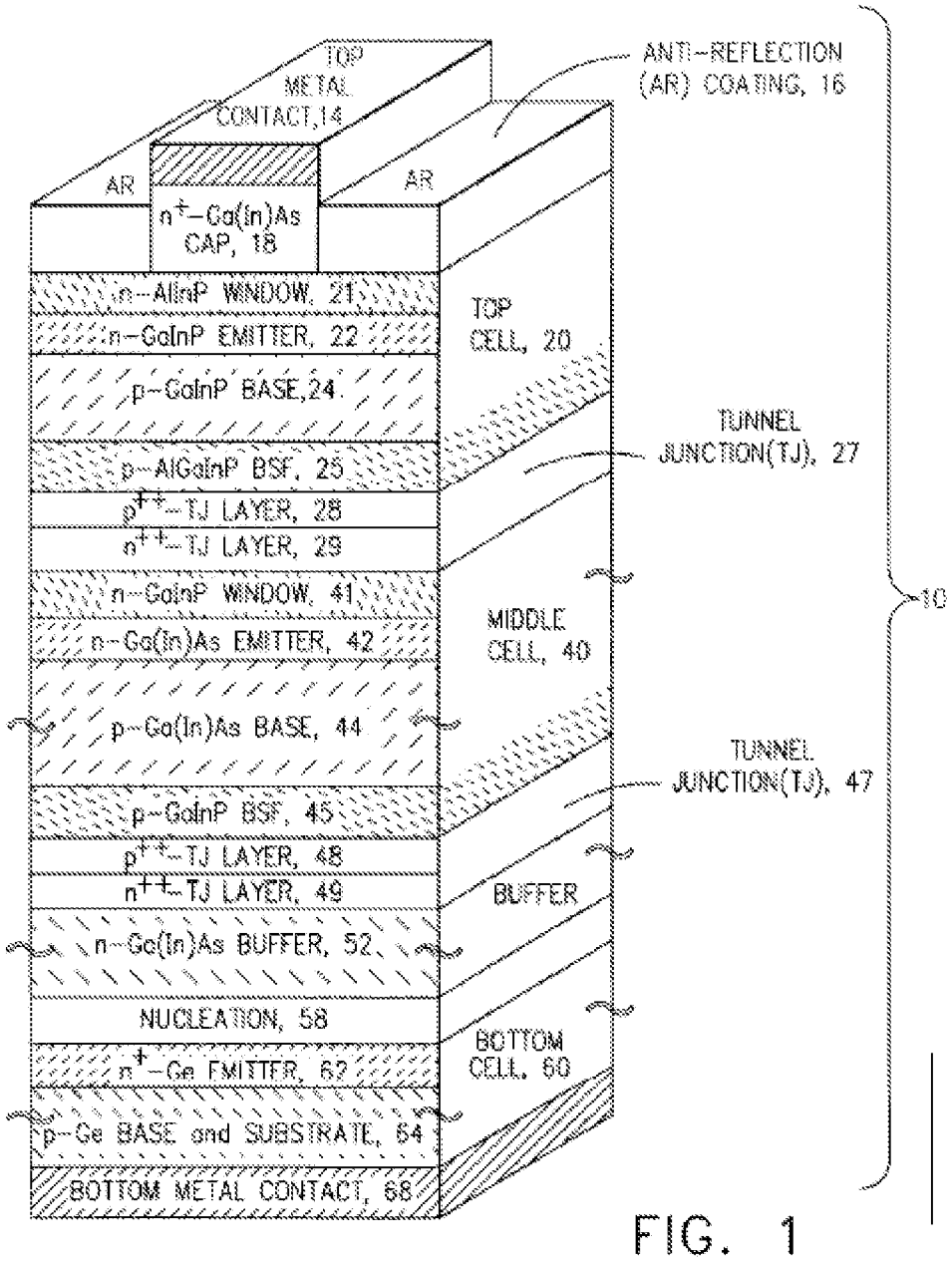

FIG. 1

Figure 1 depicts "a cross-section of a 3-junction photovoltaic cell." King ¶ 29. The structure contains three cells, of which the top cell **20** includes, from top to bottom, p-AlInP window **21**, n-GaInP emitter **22**, p-GaInP base **24**, and p-AlCaInP BSF (back-surface field) layer **25**. According to King, "a

variety of different semiconductor materials may be used" for the emitter layer **22**, the base layer **24**, and the BSF layer **25**,

> including AlInP, AlAs, AlP, AlGaInP, AlGaAsP, AlGaInAs, AlGaInPAs, GaInP, GaInAs, GaInPAs, AlGaAs, AlInAs, AlInPAs, GaAsSb, AlAsSb, GaAlAsSb, AlInSb, GaInSb, AlGaInSb, AlN, GaN, InN, GaInN, AlGaInN, GaInNAs, AlGaInNAs, Ge, Si, SiGe, ZnSSe, CdSSe, and other materials and still fall within the spirit of the present invention.

Id. ¶ 46.

King discloses a similar embodiment in Figure 2, where window **71**, emitter **72**, base **74**, and BSF layer **75** correspond, respectively, to layers **21**, **22**, **24**, and **25** in Figure 1. *See* King Figs. 1, 2. Layers **71**, **72**, **74**, and **75** may comprise any of the same list of semiconductor materials listed above. *See id.* ¶ 82. King also states that

> [t]he photovoltaic cell **70** may be of either a homojunction or heterojunction design. In a homojunction design, the semiconductor material in the emitter layer and base layer has the same composition, with the exception of the different doping in the emitter layer **72** and base layer **74**, and the same semiconductor bandgap. The PV cell **70** is presented [in Figure 2] as a homojunction cell.

Id. ¶ 84.

The Examiner finds that the first layer in claim 1 corresponds to the "homojunction formed between the emitter layer (**22**) and the base layer (**24**) which comprise the same semiconductor material," which may be a group IV material. Final Action 7–8 (emphasis added) (citing King Fig. 1, ¶¶ 46, 80, 84). The Examiner also finds that the second layer of claim 1 reads on either BSF layer **25** or the tunnel junction layer **27** of King. In the case of BSF layer **25**, it may be a group IV or III–V material, or in the case of tunnel junction **27**, it may be a III–V material. *See id.* at 8–9 (citing King ¶¶ 21–23,

46, 73). According to the Examiner, King also teaches that the second layer has the same doping type as the first layer. *See id.* (citing Fig. 1, ¶ 23).

Given the disclosures of King, the Examiner concludes that it would have been obvious to select the materials for each of the layers as required by claim 1. In particular, the Examiner determines that the selection is among a finite group of predictable materials (i.e., selecting groups IV and/or III–V from among the groups disclosed by King), that it would have been within the ordinary skill in the art to try combinations of the two semiconductor classes as recited in the claim, *see id.* at 9, and that a skilled artisan would have expected the materials thus selected to work as intended, *see* Answer 20. The Examiner also determines that forming the cell defined by claim 1 would have merely been a selection of known materials based on their suitability for their intended use, which according to the Examiner is sufficient to support a prima facie case of obviousness. *See id.* (citing *Sinclair & Carroll Co. v. Interchemical Corp.*, 325 U.S. 327, 335 (1945)).

Appellants argue that King discloses 31 materials for use in the layers, and that the disclosure of such a broad field of prior art materials (which could lead to "hundreds or thousands or tens of thousands of hypothetical multijunction solar cells") does not render their combination obvious absent some direction or teaching for making such a selection. *See* Appeal Br. 6 (citing *Leo Pharm. Prods., Ltd. v. Rea*, 726 F.3d 1346, 1356 (Fed. Cir. 2013); *Rolls-Royce PLC v. United Techs. Corp.*, 603 F.3d 1325, 1339 (Fed. Cir. 2010)); *see also* Reply Br.[5] 5–8.

[5] Reply Brief, Feb. 22, 2016.

We do not find this argument persuasive of reversible error in the rejection. While King discloses a list of 31 materials from which layers **22**, **24**, and **25** (or equivalently, layers **72**, **74**, and **75**) may be constructed, claim 1 is not directed to specific materials; rather, it is directed to group IV or III–V materials as classes. One may divide the 31 compounds that King discloses into group III–V materials, group IV materials, and group II–VI materials (ZnSSe and CdSSe). *See* King ¶¶ 46, 82. Thus, when viewed in terms of the material type, King only discloses three choices of material for each layer.

In addition, unlike in *Leo Pharm. Prods.* and *Rolls-Royce*, King discloses more than just a "broad selection of choices for further investigation" from among multiple references. *Leo Pharm. Prods., Ltd.*, 726 F.3d at 1356 (quoting *Rolls–Royce PLC*, 603 F.3d at 1339). Appellants have not directed our attention to any persuasive evidence that selecting a combination of material classes (group IV and/or III–V) according to claim 1 would have required more than ordinary skill and common sense, or that a skilled artisan would have had no good reason to pursue such combinations. *See KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007).

Appellants further argue that the Examiner's findings in support of obviousness are conclusory statements without sufficient evidentiary backing to establish a prima facie case of obviousness. Reply Br. 4–5 (citing Answer 18–19). We disagree. The Examiner has persuasively shown that King teaches a finite number of predictable material classes (e.g., group IV and III–V), teaches that layers corresponding to the first and second layers of claim 1 may be selected from among those classes, and teaches that such combinations are suitable for successfully forming a photovoltaic cell. *See*

Final Action 9; Answer 18–21. Thus, the Examiner presents "articulated reasoning with some rational underpinning to support the legal conclusion of obviousness." *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006). By a preponderance of the evidence on this record, the Examiner's findings and conclusions are sufficient to establish a prima facie case of obviousness.

Appellants also argue that Welser[6] and Gudovskikh[7] teach away from a heterojunction comprising a group IV material and a group III–V material. *See* Appeal Br. 7–8; *see also* Reply Br. 8. Appellants argue that "Welser teaches that the uncontrolled doping of a Group III-V semiconductor material by a Group IV material is so detrimental to device performance that great effort must be undertaken to ensure that such doping does not occur." *Id.* at 7. Appellants argue that Gudovskikh teaches that "heterointerfaces can impair the quality and performance of multijunction solar cells for a variety of reasons," and "that these problems can be especially acute for interfaces between a Group III-V material and a Group IV material, even when there is no p-n junction between the materials." *Id.*

We do not find this argument persuasive of reversible error. To teach away, a reference must "criticize, discredit, or otherwise discourage the solution claimed" by Appellants. *In re Fulton*, 391 F.3d 1195, 1201 (Fed. Cir. 2004). As the Examiner correctly notes, Welser does not teach against the production of photovoltaic cells with III–V/IV heterojunctions, only that high quality group III–V and Ge (a group IV element) layers cannot be made

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[6] E. Welser et al., *Memory Effect of Ge in III–V Semiconductors*, 310 J. CRYSTAL GROWTH 4799 (2008).
[7] Alexander S. Gudovskikh et al., *Chapter 18: Interfaces in III–V High Efficiency Solar Cells*, *in* HIGH EFFICIENCY SOLAR CELLS: PHYSICS, MATERIALS, AND DEVICES 545 (X. Wang & Z.M. Wang eds., 2014).

in the same MOVPE (metalorganic vapor phase epitaxy) process. *See* Answer 27–28 (citing Welser 4802). Appellants do not point to any evidence that MOVPE is the only way a person of ordinary skill in the art would have made III–V/IV heterojunctions, and does not dispute the Examiner's finding that King does not teach or require the use of MOVPE. *See* Answer 27.

Likewise, Appellants have not shown that Gudovskikh teaches away from the production of III–V/IV heterointerfaces, only that there are factors that may impair the performance of such junctions in photovoltaic cells. *See* Appeal Br. 7; *see also* Reply Br. 8 (arguing that Welser teaches that "greater effort must be undertaken to ensure that [uncontrolled] doping [of a III–V material into a IV material] does not occur, ***regardless of how the device is made***"). However, Appellants do not direct our attention to any teaching that such problems are insurmountable by using the ordinary knowledge and skill available in the art. Finally, we note that neither Welser nor Gudovskikh address a heterojunction in which both the first and second layers comprise IV materials, which is an embodiment within the scope of claim 1.

Appellants also argue that the claims are nonobvious because the Specification shows evidences of unexpected results. *See* Appeal Br. 8; *see also* Reply Br. 8–9. According to Appellants, "in contrast to the expectations of a person of ordinary skill in the art, . . . Applicants have discovered that it is in fact possible to provide useful solar cell devices having a III-V/IV heterointerface." *Id.* Appellants argue that "such devices can exhibit not only acceptable performance but also improved performance compared to some prior solar cells." *Id.* In particular, Appellants argue that the

Specification describes such a junction, which "exhibited an improved open-circuit voltage compared to a device lacking this heterojunction," and that such a structure "can increase the voltage, current, fill factor, and/or efficiency of a photovoltaic cell." *Id.* (citing Spec. 30–32, Fig. 18).

Figure 18 of the Specification, which Appellants rely upon as evidence of unexpected results, is reproduced below:

FIG. 18

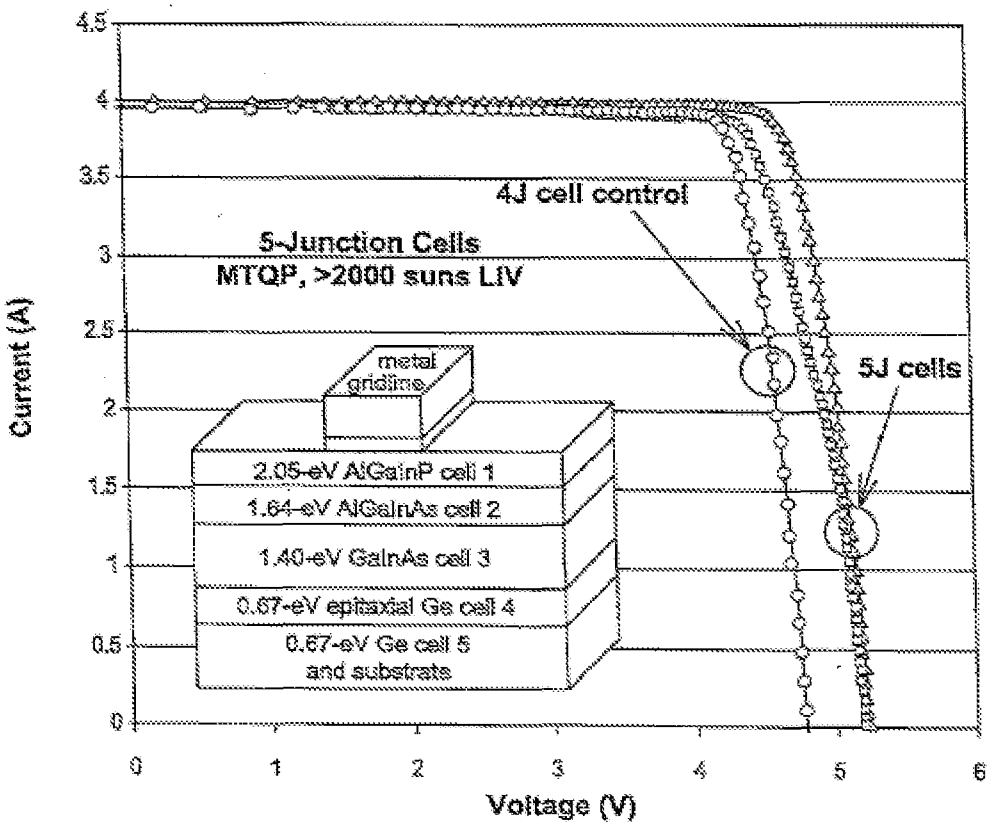

Figure 18 depicts the "measured light I-V characteristics of two fully-integrated prototype 5-junction (5J) cells, incorporating a heterojunction epitaxial Ge cell 4." Spec. 31. The figure marks the curves for the 5J cells with triangles and squares, as compared to a "4J cell control" marked with circles. *See id.* The 4J cell "has the same structure as the 5J cells except that the epitaxial Ge cell 4 and associated tunnel junction are absent." *Id.* The Specification concludes that

> a preferred solar cell comprises additional heterostructure layer(s) having higher bandgap(s) than the first photoabsorbing layer, in order: 1) to reduce unwanted photoabsorption in the additional heterostructure layers(s); 2) to suppress minority-carrier recombination within and at one or more surfaces of the additional heterostructure layer; and/or 3) to reduce unwanted dopant or other impurity diffusion from one part of the solar cell to another, particularly since many of these heterostructures may include both group-IV and III-V semiconductors in adjacent layers, and the elements in these different families of semiconductors act as dopants in the other family of semiconductors, a phenomenon termed here as cross-column doping, referring to the columns in the periodic table of elements.

Id.

As the Examiner correctly determines, Appellants' evidence of unexpected results is not commensurate with the scope of the invention in claim 1, because "[t]he showings in Figure 18 are directed to the particular combination of different cells/subcells rather than the layers and/or heterointerfaces formed within said subcells." Answer 30. Moreover, Appellants have not shown that the improvements in Figure 18 or elsewhere in the Specification are due to the specific two-layer structure recited in claim 1, or are commensurate with its full scope, which may include either a III–V/IV or a IV/IV heterojunction. *See In re Harris*, 409 F.3d 1339, 1343 (Fed. Cir. 2005) (holding that the appellant needed to show results covering the scope of the claimed range, or else narrow the claims). Appellants also have pointed to no evidence that the results in Figure 18 would have been unexpected to a person of ordinary skill in the art. *See In re Klosak*, 455 F.2d 1077, 1080 (CCPA 1972) ("[I]t is not enough to show that results are obtained which differ from those obtained in the prior art: that difference must be shown to be an *unexpected* difference.").

> In the Reply Brief, Appellants state that
>
> > the Examiner's Answer notes that [claim 1] do[es] not require the recited heterojunction to be between a Group III-V material and a Group IV material. Applicants do not disagree. However, Applicants note that other claims, ***such as dependent claims 5 and 15***, do recite a first layer formed from a Group IV material and a second layer formed from a Group III-V material.

Reply Br. 4. Appellants then proceed, in the Reply Brief, to compare the distinguishing limitations of claims 5 and 15 with the disclosures of King. *See* Reply Br. 4–9.

Appellants did not make arguments regarding claims 5 and 15 in the Appeal Brief, and the new arguments are not responsive to arguments raised by the Examiner in the Answer. Therefore, we do not consider Appellants' new arguments for purposes of this appeal. *See* 37 C.F.R. § 41.41(b)(2).

For the above reasons, Appellants have not persuaded us that the Examiner reversibly erred in rejecting claim 1 under 35 U.S.C. § 103(a). For the same reasons, Appellants have not persuaded us of reversible error in the rejections of claims 2–13 and 15–18.

Because Appellants do not contest provisional double patenting rejections I and II, we summarily affirm those rejections. *See Hyatt v. Dudas*, 551 F.3d 1307, 1314 (Fed. Cir. 2008) (holding that the Board need not consider the merits of an uncontested ground of rejection).

DECISION

The Examiner's decision rejecting claims 1–13 and 15–18 is affirmed.

No time period for taking any subsequent action in connection with this appeal may be extended. *See* 37 C.F.R. § 1.136(a)(1)(iv) (2016).

AFFIRMED